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EDITORIAL

Modern Building

IT has been said that this age of architecture is identified with steel, as was Egyptian architecture with sandstone, Assyrian with clay, and Greek and Roman with marble. Yet it is only fifty years, as we read recently, since a steel frame was first used to carry the complete weight of a building. What changes this fifty years has seen! What greater changes may be expected in the next fifty years? The question is one we shall not attempt to answer, for the trend of modern building practice can hardly be said to be pointing consistently in one direction. Modern building has a wide scope. On the one hand we have the skyscrapers of New York, some noble edifices in New Delhi and Liverpool, Broadcasting House, and some examples of modern design to which perhaps all of us are not yet reconciled in Fleet Street and Stratford-on-Avon: on the other hand we have huddled groups of suburban dwellings, in the building of which cheapness has been a prime consideration, containing too many cheap bricks and nasty slates to be likeable even if their monotony of repetition were of no account, country cottages, and all the imitative "ye olde" buildings, pseudo-Tudor, pseudo-Elizabethan, and pseudo almost everything. Of much of this modern building posterity may well be proud: of a deal of it too the succeeding generations may perhaps rightly be scornful, even as we now regard the ornate Victorian dwellings that succeeded the clean simplicity of those of Georgian times. We have perhaps no architecture that can be called typical of the decade, but there is every indication of progress in building practice. Thus many new University buildings are both noble and suited to their purpose, and though we may deplore the obliteration of many a pleasant country lane, it is something to feel that the obliterating buildings are the alternative to the congestion and squalor of crowded cities. Many factories too are excellently designed. We have perhaps wandered from the original purpose of this article, which was to call attention to the modern builders' variety of materials. Not least of the architect's problems to-day is to decide which materials are most suited to his purpose, and which of the newer materials can be used with assurance of good service. Steel may continue to be the basis of modern architecture, but around such a frame-work the architect may fill in the details of his design with stone, brick, cement, metal, wood, and glass, and for roofing he may use tiles, slates, sheet metal, glass, or other coverings, whilst when he comes to the matter of interior construction he has a host of materials to consider. In a recent lecture at the Science Museum, South Kensington, Mr. Raymond McGrath, the architect who has used plastics to such good purpose in Broadcasting House, said that with adequate technical information available architects would be willing and anxious to use plastic materials. We hear in this, with no great regret, the doom of the wall-paper: distemper may also go. Plastics will certainly find considerable use in future building. But in addition, with increasing attention to heat insulation and acoustics, fibre boards will probably come into greater use, and there is no knowing the extent to which light alloys will be employed. The Mellon institute has already given us cellular metal floors, and similar developments are only to be expected from this and other establishments where building research is rapidly going forward. The architect of the future, it seems, will have to be something of a chemist, and will certainly have to be possessed of a knowledge of metallurgy. Even as we write, we have before us an illustration of Monel metal sinks and drainboards installed in a private residence, and another illustration shows a striking effect achieved by the use of "Staybrite" nickel-chromium steel for a shop-front. Add to these the attention which is at present being given to fire-resistant compositions, and it is easy to see what a variety of materials science is giving the architect, although perhaps their abundance may embarrass him temporarily until he has been able to compare and evaluate their usefulness.

The Farmer and the Chemist

Chemistry entered into farming with Liebig, and since the days of Lawes and Gilbert there has been a steady increase in the application of chemical manures to the land coupled with a diminution in their cost and an appreciation in their value. Agricultural stations far too numerous to mention are in being and adding their quota to the scientific knowledge of the soil, of grass, of stock feeding, and much besides: the farmer is given every opportunity to acquire knowledge and abandon the rule-of-thumb methods of the past. Though from a multitude of causes things are anything but well with farming—the outstanding factor being the low price of agricultural produce—it is perhaps necessary to contemplate that there will be no revival unless farming changes its methods, takes more heed of science, becomes industrialized. We are informed that in Germany farming is developing as a learned profession, the farms are becoming mechanized, foodstuffs are being produced on the largest scale, the by-products of the land are being utilized as the starting point for synthetic manufactures, all this activity being fostered by the desire to develop a national spirit and the national resources to the utmost and to limit the purchase of foreign materials, above all of foodstuffs. In Britain our problem is somewhat different for there is the Empire to contribute to our needs and to make up our deficiencies, but we raise too little food at home, buy far too much from abroad largely because its price is more favourable; either the home cost of production is too high or the marketing organisation inadequate, or the farmer is failing to work along modern lines. The League of Science, so energetically conducted by Mr. W. P. Dreaper, is constantly giving examples of what can be done in the production of either cereals, meat, milk, or eggs, and the canning factories afford an example of a definite positive achievement in home production. There would seem to be room for a much closer liaison between the farmer and the chemist, between farming and the chemical industry. They are substantial customers of one another and can be mutually helpful. The industrial worker will be prepared even to pay a little more for his loaf or his vegetables if he is assured they are fertilized with British-made manures and dug with British spades and forks and hence giving employment at home. The chemist has invented many new processes using the products of the farm as raw materials which are on the point of becoming economic; these will serve in time to produce at home commodities which are now imported. Alcohol will replace petrol, sugar can be made from wood, rayon from wood pulp is replacing imported cotton, flax may be grown at home, synthetic rubber is a possibility, the novel products of the fermentation industries are numerous. Ammonia from the air displaces Chili nitrates, basic slag from the Bessemer furnace produces essential phosphates. The work of the chemical industry and of the farmer needs co-ordination; the Farmers' Union should sit round the table with the representatives of chemical industry, seeking ways of co-operation and mutual support for the benefit of both industries and of the community. To-day those who initiate action generally ask, "Is it likely to result in money profit? Will it earn interest?" In a more ideal state we migl plan for socially valuable ends, for consumption an use, not for restriction of production or money profit.

Patent Litigation

The litigation between the British Celanese Co. an Courtaulds as to the validity of certain patents fc spinning rayon threads has taken up a great deal c time and no doubt has cost a vast amount of mone The decision of the Court of Appeal is an important or and the judgment of the Master of the Rolls is we worth reading by those whose profession or inclinatio makes such reading an interesting study. Litigation i this country is doubtless expensive but no one can den that actions in the Supreme Court are distinguished b an intense desire to ascertain the facts, so far as th old-established law of evidence permits, and to spare n pains in weighing them, so that the judge or judges ca do all that is possible to come to a fair and careft decision. Mr. Justice Clauson listened to the details c evidence and learned statements about the law c patents (with the bulk of which he was no doubt alread familiar) for thirty-five days and we may be sure tha every argument for or against the validity of the patent that the ingenuity of counsel could suggest, was patientl and carefully considered. The first patent B.P. 165,51 was in 1920 and was for the spinning downwards c threads forced through fine holes, at a proper speec and with clever devices for winding, drying the thread and so on. The Court of Appeal spent seventeen day in reviewing the decision of Mr. Justice Clauson tha this patent was invalid and the Master of the Roll explained in his judgment that the claim of the Celanes Company was for an aggregation of the downwar spinning, the special speed, the evaporative casing good recovery of the solvent, and so forth. Accordin to the judgment of the Court of Appeal each one par ticular feature that was relied upon had been anticipate by other inventors, notably Clark in 1887, Lehner i 1891, Birsch and others, and the mere addition o a number of old devices did not give ground for a vali patent. It seems to us as if the learned judges regarde the matter as a beginner in chemistry is advised to do If you add sand to sugar or alum to flour you ar forming no new substance; contrariwise, if you trea iron with an acid new substances will arise. W presume that a combination of old mechanical principle in a new method giving results that no one could antici pate would form the basis of a valid patent but th mere addition of invalid claims will not. The distinc tion is analogous to the distinction between addition an multiplication, and is analogous to the distinctio between mixtures and compounds and obviously ther will be many border-line cases hard to distinguish. Th particular patents in this case seem to have impresse the members of the Court of Appeal in the same way fo they were unanimous in declaring them invalid. W wish we could remember the name of the case when so it is alleged, the senior judge began by saying: "W have come to a unanimous decision, not even our dea brother Bramwell dissenting."

THE PRODUCTION AND USES OF SOLID CO_2 *

By Dr. H. G. LITTLER

It is very seldom that a chemical compound can remain a well-known denizen in the scientific laboratory for nearly a hundred years without anyone suspecting that it may have important industrial applications. Yet this happens to be the case with solid CO_2, which was discovered ninety-eight years ago by Thilorier and only produced commercially for the first time in 1924. The fact is the more remarkable, because the production of solid CO_2 is by no means very difficult as industrial processes go, and its application as a refrigerant is obvious enough, although the methods that must be adopted if success is to be achieved are sometimes a little involved.

During the interval of time between the discovery of solid CO_2, ninety-eight years ago, and its commercial production in 1924, only two people, so far as I know, gave very serious thought to its commercial possibilities. These two people were Dr. Elworthy and Mr. Slate. But during this period of its commercial obscurity one cannot say that solid CO_2 was born to sublime unseen and waste its coldness on the laboratory air, for experimenters turned to it thankfully as a means of obtaining low temperatures, and lecturers found it invaluable for teaching students of the phase rule the grand basic truth that substances can, and some substances do, have boiling points colder than their freezing points.

Both Elworthy and Slate however, thought solid CO_2 had commercial possibilities. Elworthy was a doctor in the British Army Medical Corps stationed in India, and one of the many troubles in his life was the difficulty of preparing good whisky and soda, particularly while on the move. This difficulty arose from the weight of the heavy cylinders used to contain the liquid carbon dioxide for aerating the soda water. Elworthy thereupon conceived the idea of solidifying his CO_2 and carrying round only about the net weight of this essential constituent of soda water. He was so pleased with this idea that he patented it and now, thirty-five years later, his idea is being exploited commercially.

Slate, on the other hand, was impressed with the possibilities of solid CO_2 as a refrigerant, and it was due to his enthusiasm that the first plant for the manufacture of solid carbon dioxide was erected in Montreal in 1924. Slate thought that solid CO_2 would easily replace ice as a refrigerant in railway cars, but his experiments in this direction were not very successful. He finally tired of solid CO_2, went to California, and applied his inventive talents to the construction of airships. The solid CO_2 plant that he had helped to create remained, however, and became the focus of a new industry. After various unsuccessful trials, solid carbon dioxide found its first field of usefulness in the ice-cream industry. Under the name of "Dry Ice" the first sale took place to Schrafft's Stores, New York, in 1925. The dry ice was used by Schrafft's as a means of counteracting the effects of the New York summer on the ice cream in small packets taken home by customers. Schrafft's experiment became famous. Other ice-cream manufacturers turned to the new refrigerant as a means of increasing their sales of ice cream, and the solid CO_2 industry was successfully launched; how successfully can be seen from the following figures which show the production of dry ice in the U.S.A. during the years 1925 to 1930. (The figures are taken from Ice and Refrigeration, January, 1932.) 1925 170 tons, 1926 525 t., 1927 1715 t., 1928 7000 t., 1929 22,000 t., 1930 40,000 t. For a time dry ice was used wholly as a means of conserving ice cream in transit. The size of the American ice-cream industry was sufficient to ensure an ample market for all the dry ice that could be produced. It was soon discovered however that solid CO_2 had important applications besides the preservation of ice cream, but it is only within the last year or so that the saturation of the U.S. ice-cream market has given the fillip necessary for their development in America. In England, with a very much smaller ice-cream trade, attempts to work out the other applications of dry ice had to be made at an early stage in the life of the solid CO_2 industry and, in consequence, the methods of application of solid carbon dioxide are probably more completely developed here than in any other country in the world.

Before going on to describe the uses of solid CO_2 and the methods of application it is necessary to say a few words about its production. Dry ice was first produced commercially by a method similar to that used in the laboratory. That is, liquid CO_2 was throttled to one atmosphere pressure and the white powder produced was hydraulically compressed into cakes. If 1 lb. of liquid CO_2 is throttled in this way, about 0·3 lb. of solid is produced (the actual amount depends on the temperature of the liquid before throttling); thus, about 70% of the original liquid is evolved as gas in the throttling process. In the laboratory this gas is allowed to escape; but as pure CO_2 gas is a valuable material, in industry the gas is collected and reliquefied. The earlier dry-ice plants worked on this simple cycle, but it was soon realized that since the production of dry ice involves a system having only one component (a very rare case in the chemical industry), the thermodynamics of the process could be worked out to a remarkable degree of completeness. Therefore, as soon as the industry began to flourish, people on both sides of the Atlantic set to work to elucidate the many problems involved in the production

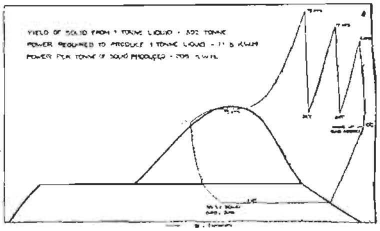


FIG. 1

* Read before a joint meeting of the Edinburgh Sections of the Society of Chemical Industry and The Institute of Chemistry, on Mar. 23, 1933.

of solid CO_2. This thermodynamic analysis yielded surprisingly good results, and the process of manufacture was greatly cheapened. This is well illustrated by comparing *on the Gibbs' T.ϕ diagram the cycle used originally* in the manufacture of dry ice, Fig. 1, with one of the cycles now employed, Fig. 2. It will be seen that the

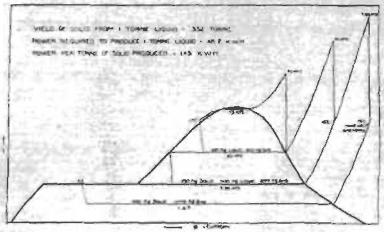


Fig. 2

theoretical power consumption has been reduced from 208 kw.-hr. to 145 kw.-hr. per tonne of solid CO_2 produced. In modern plants a number of different cycles are employed each one claiming certain thermodynamic advantages. These cycles differ little among themselves in efficiency, but are all over 30% more efficient than the cycle originally used. Their development illustrates very aptly *how a somewhat abstruse science can be* directly applied to industry and effect great economies. Perhaps one of the most complimentary things that can be said about solid CO_2 is that it caused the lion of Willard Gibbs to lie down with the lamb of ice cream.

It has been repeatedly stated in the literature that CO_2 gas from almost any source can be used in the manufacture of dry ice. While this statement is true, it must be accepted with one very important reservation, namely, that the gas, from whatever source it be obtained must readily be purified. The impurities which render a gas unsuitable for dry-ice manufacture are of two types. The first are odoriferous compounds whose presence gives the dry ice an unpleasant taste or smell. These compounds naturally vary with the source of the gas. They may be sulphur compounds in industrial gases, organic esters, and the like in fermentation gases, or hydrocarbons in natural gas. As a rule the impurity tends to concentrate in the dry ice, and although by no *means all the CO_2 put into the plant emerges as* dry ice, the solid which is produced contains all the impurity originally present in the gas. It must be borne in mind that solid CO_2 is used in the most intimate possible contact with foodstuffs, and in consequence, the smallest trace of malodorous impurity renders the dry ice useless. Inconceivably minute traces of certain compounds in the CO_2 gas will ruin the dry ice produced. For example, we have found it necessary to reduce the concentration of certain of the impurities to less than one part per million in order to be assured of an absolutely satisfactory product, *a fact which emphasizes the tendency* of modern chemical industry to work to purities which, fifty years ago, were only achieved in the laboratory for such experiments as the determination of atomic weights.

The second type of impurities are non-condensil gases, air, hydrogen, nitrogen, etc., which at first sig look harmless enough, as it might be supposed th *they could readily be separated from the CO_2 aft* liquefaction. Up to a point this is true, but carbo dioxide happens to be a compound which exhibi retrograde condensation to a remarkable degree and will be found that under certain conditions the liqu CO_2 will dissolve in the gaseous phase to give a singl phase system. Thus a plant may run perfectly w during most of the year and become completely u *workable with a rise of a few degrees in the temperatu* of the cooling water. The only way to be certain the effects which will be produced by the "inerts" any given gas is to work out the phase rule diagram the system.

Two other problems in the production of dry i should be mentioned. The first is the possibility contamination of the solid CO_2 by oil carried over fro *the compressors.* This was a serious difficulty in th early dry-ice plants, but has now been solved by combination of special oils and oil filters. Drikol for example, contains less than 0·001% of oil. Tl second problem is the presence of water vapour in th gas. Liquid CO_2 will dissolve about 0·04% of water ordinary temperatures. At +10° C. this water separat out as the hexahydrate, $CO_2 \cdot 6H_2O$, and causes endle trouble due to chokes. *To avoid this the gas is dried* the most common agents employed are sulphuric aci calcium chloride, or silica gel.

The dry ice produced by different processes diffe only very slightly in physical properties. The followin list of properties can be taken therefore as typical good commercial solid carbon dioxide. In appearan dry ice looks like compressed snow. It is usuall produced in 10-in. cubes weighing 50 lb., or 7-in diameter cylinders, 14 in. long, weighing 25 lb. Owin to the triple point of carbon dioxide being at a pressu *higher than atmospheric,* dry ice passes directly int gas under an external pressure of one atmosphere of CO The temperature at which this evaporation takes pla

Fig. 3

is −78·9° C. The system gaseous-solid CO_2 ha *one degree of freedom, so that if the pressure of gaseou* CO_2 is altered the temperature of the solid varies. Thi happens, naturally, when blocks of dry ice are lifted int the air from packages in which there is an atmospher of CO_2. The resultant temperature drop which occur

of course, at first on the surface, causes the skin of the block to contract and sets up temperature stresses. Unless the block is plastic enough to take up these stresses by shrinkage, it will fly to pieces. This has an important bearing on the density of dry-ice blocks. The maximum theoretical density is 1·56, but densities much over 1·4 are liable to make the block so rigid that it will burst when suddenly exposed to the air.

The heat of sublimation of solid CO_2 is 137 kg.-cal./kg. at $-78 \cdot 9^\circ$ C. If the resulting gas be allowed to heat up to 0° C. the increase in enthalpy accounts for another 15 kg.-cal. Compared with water ice therefore, dry ice is about twice as effective weight for weight and three times as effective volume for volume.

In view of its extremely low temperature one would have supposed that dry ice would be almost impossible to handle commercially because of the high evaporation losses. This, however, is not found to be so in practice. On the contrary, because of its high latent heat and density together with the insulating properties of its blanket of vapour, dry ice is surprisingly stable. After some experience with various insulators it has been found that dry ice can be stored for prolonged periods with only small losses. Indeed, the length of storage is limited not so much by the evaporation losses as by the growth of the crystals of solid CO_2, which renders the blocks friable.

For these reasons it has been found possible to distribute dry ice over a wide area from a central producing unit. In the early days of the industry it was thought that long-distance transport would be impossible and that the right organization for the dry-ice industry was a number of small plants situated at the centres of consumption. The obvious disadvantages of this arrangement were that, as with all small units, mechanization was practically impossible, and that no use could be made of natural or by-product carbon dioxide unless,

FIG. 4

by some fortunate chance, the waste CO_2 was situated near the dry-ice consuming centre. In consequence, the CO_2 had to be generated by burning coke—an expensive business. With the evolution of the technique of storage and long-distance transport, large producing units utilizing waste carbon dioxide came into being. In this country solid CO_2 is distributed from Billingham to almost all parts of the United Kingdom, and stocks are held in most of the large towns.

A special type of container has been evolved in collaboration with the London & North Eastern Railway for the transport of dry ice. Some of these containers

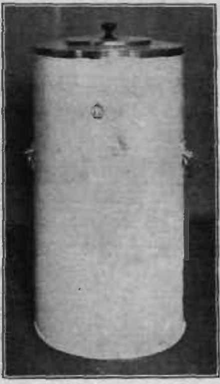


FIG. 5

are shown in Fig. 3, and a typical storage bin is shown in Fig. 4. This particular bin is at Birmingham. The losses in transit from the container, which holds just over 2 tons, are about $1\frac{1}{2}\%$ for 24 hours, the actual amount depending to some extent on the external temperature. One of the problems to be solved in the design of this system of distribution was to eliminate all risk of the operatives being suffocated by the evolved CO_2 gas. By taking advantage of the fact that cold CO_2 gas is much denser than air, all risk was avoided by so arranging matters that every operation was performed on a level well below that of the workers' heads. This precaution has proved completely successful.

The two main uses to which solid CO_2 has been put are those foreseen by Slate and Elworthy, namely, its use as a refrigerant and as a source of gaseous CO_2. The economics of the use of solid CO_2 as a refrigerant present certain very interesting features. At first sight it would appear that dry ice will come into direct competition with water ice and mechanical refrigeration. A little consideration, however, shows that this view of the situation is not strictly correct. It ignores that most important of factors, temperature.

All heat absorbed by dry ice is taken in at a temperature of $-78 \cdot 9^\circ$ C., *i.e.*, at $78 \cdot 9^\circ$ lower down the temperature scale than the heat absorbed by water ice. We can see at once, therefore, from the second law of thermodynamics, that dry ice is going to require much more power to produce than is water ice. Calculation shows that with an ideal engine working with an upper limit of 15° C., it requires 15·05 times as much power to

produce 1 lb. of dry ice as to produce 1 lb. of water ice. This is reflected in the price of the two commodities. A pound of dry ice costs about twenty times as much as a pound of water ice.

The same argument applies with equal force when a comparison is made between the costs of refrigeration

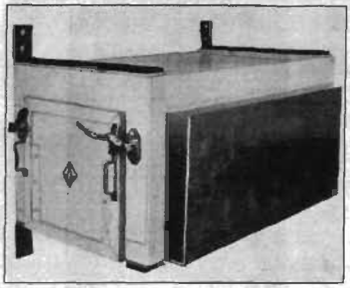


FIG. 6

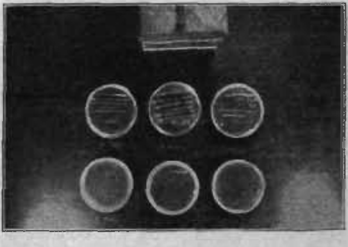
at 0° C. by means of mechanical units and by means of dry ice. Clearly, however, the lower the required temperature of refrigeration the greater the efficiency of dry ice in comparison with water ice or mechanical units, until at $-78 \cdot 9°$ C., dry ice becomes the most efficient refrigerant known.

It is not surprising therefore to find that dry ice was first used as a refrigerant to conserve ice cream, where relatively low temperatures are required. This preservation of frozen products at low temperatures is still an important field for solid CO_2. Fig. 5 shows a typical conservator used for the preservation of ice cream by means of dry ice. As the use of quick frozen foods increases, this field of application will greatly expand. Dry ice is, however, used with success in other fields of refrigeration besides low-temperature conservation, and in these fields its success depends upon the commercial value to be placed upon its physical properties other than its temperature and latent heat. No general statement can be made as to where dry ice can be economically used as a refrigerant; each case must be examined on its merits. Its properties do, however, make solid CO_2 the ideal cooling agent for certain types of refrigerated transport.

We can summarize the advantages of dry ice as a refrigerant in transport over ice, ice and salt mixtures, or mechanical units, as follows: (1) Low capital cost of installation. Comparatively simple and cheap apparatus is all that is necessary for utilization of dry ice. (2) Low maintenance costs. The maintenance on cars refrigerated with solid CO_2 is not greater than on standard rolling stock. (3) General utility of the refrigerated cars. A tremendously wide range of temperatures is available and the same car can be used for the transport of fresh meat or frozen salmon by means of a simple adjustment to the dry-ice units. (4) Mobility of the cars. A train may be broken up and assembled in any order and the cars may be allowed to stand in sidings without affecting the refrigeration. (5) Lightness. This is particularly important for road transport but is also an important factor in refrigerated railway containers. For these vehicles, dry ice is virtually the only refrigerant that can be used. (6) The effects of the evolved CO_2 gas. The gas has two beneficial effects which will be dealt with later.

The fundamental problem to be solved in the use of dry ice as a refrigerant is the control of temperature. Solid CO_2 is in almost all cases at a lower temperature than the goods to be refrigerated. Further, blocks of dry ice evaporate at different rates depending on their size. The rate of evaporation is proportional to the surface, so that the rate of evaporation falls off as the block sublimes. This means that, without special precaution, any space kept cool with solid CO_2 will have a minimum temperature when the dry-ice blocks are first introduced and a maximum temperature when the blocks have all but evaporated. To overcome these two difficulties the following type of apparatus is used.

The blocks of solid CO_2 are placed in a small bunker insulated on all sides but one. This bunker is introduced into the space to be refrigerated and the heat withdrawn from this space is conducted, by means of a plate of metal, to the dry-ice blocks in the insulated bunker. As, however, the dry-ice chamber is insulated on all sides but one, the blocks of solid CO_2 will evaporate at one surface only. This surface is practically constant, and so a constant rate of evaporation is ensured. To vary the rate of evaporation, and hence the temperature in the refrigerant chamber, it is only necessary to introduce a thermal resistance between the dry ice and the metal conductor plate. As this resistance can easily be varied, any desired temperature down to $-78 \cdot 9°$ C. can be maintained in the refrigerated space. A typical evaporator unit of this simple type is shown in Fig. 6. This unit is in use on the British railways, of whom one is bound to speak in terms of the highest praise



1 Air 2 Air 3 Air
1 CO_2 2 CO_2 3 CO_2

FIG. 7

for the rapidity with which they have grasped the value of dry ice as a refrigerant, and for the technical advances they have made in its application.

The ice-cream conservator shown in Fig. 5 embodies the same principles as the evaporator unit. In the case of the conservator the evaporator unit forms part

of the structure of the cabinet itself. This type of evaporator unit can readily be elaborated so as to maintain constant temperatures in a refrigerated space in spite of widely varying external temperatures. All that is necessary is to fit a thermostatically controlled shutter to regulate the convection currents over the cooled conductor plate.

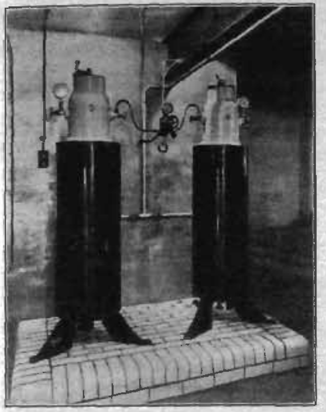


FIG. 8

We have seen that at high temperatures dry ice is a relatively inefficient refrigerant. A method has now been worked out which will, partially at any rate, overcome this defect. When refrigerating at temperatures of about 0° C. there is a temperature difference between the space to be refrigerated and the solid CO_2 of −78·9° C. In the evaporator units just discussed, no use is made of this temperature drop which is allowed to take place in an irreversible manner. From the second law of thermodynamics we know that properly harnessed this temperature difference could be utilized in the performance of useful work, and the particular work we are interested in at the moment is the abstraction of heat units from a refrigerated space. What is needed therefore is a thermodynamic engine which will render the temperature drop between the solid CO_2 and the refrigerated space less irreversible and utilise the energy thus rendered available to supplement the refrigerating power of the dry ice. We have a number of such engines on test in our laboratories, and the indications are that we shall, in effect, be able to double the refrigerating power of solid CO_2 by means of thermodynamic engines without moving parts. This will mean an extension of the uses of dry ice for relatively high temperature refrigeration.

It was mentioned earlier that the CO_2 gas evolved by dry ice had two beneficial effects. The first of these is the insulating value of the gas. Gaseous CO_2 has only about 60% of the conductivity of air. Thus by piping the evolved CO_2 gas into the insulation, the heat leak into any refrigerated space can be reduced to a theoretical minimum limit of 60% of the heat leak obtained with air as the insulator. The second effect is the bactericidal action of the CO_2. A great deal of work is being done on this subject, notably by the Food Investigation Board. Preliminary results show that, for example, fish kept in atmospheres containing CO_2 do not rot so quickly as fish kept in the same temperature in air. Fig. 7 illustrates this bactericidal effect of CO_2 very well. The six glass dishes shown have been prepared in the following way. The glasses have been filled with sterile artificial media, and have been later inoculated in pairs with a pure culture of one of the bacteria commonly found on the surface or in the intestines of fish. The two glasses labelled 1 were inoculated with the bacterium *Pseudomonas*, those labelled 2 with *Bacillus*, and those labelled 3 with *Achromobacter*. One dish of each pair was placed in an atmosphere of 100% CO_2, and the other dish in an atmosphere of air. They were then incubated for 48 hours at a temperature of 25° C., which is the optimum temperature of growth. As will be seen by comparing the top row (air) with the bottom row (CO_2), the carbon dioxide has practically prevented all growth (number 2 shows a slight trace). (For a full account of this work see J.S.C.I., 1932, Vol. 51, No. 15, pp. 119 T—121 T, paper by F. P. Coyne.)

The importance of this bactericidal effect of the CO_2 in the transport of fish is obvious enough but more important still, it opens up the possibility of the large scale preservation of fish by means of dry ice on board the trawler itself. By this means it may be possible to land fish at the ports in as fresh a condition as when caught, and to increase greatly the range of the trawlers, thus enabling them to reap the rich harvests of distant fishing grounds.

As Elworthy foresaw, dry ice can be used as a convenient source of pure CO_2 gas. Normally, CO_2 gas is transported in heavy steel bottles. A great economy in transport costs is clearly brought about if approximately only the net weight of the CO_2 has to be handled. Thus, as soon as a convenient method of converting the dry ice to liquid or gaseous CO_2 had been evolved dry ice began to be used by brewers, mineral-water manufacturers, aspirin makers, etc. as a source of carbon dioxide gas. The process of converting dry ice to liquid or gaseous CO_2 consists of supplying heat to the solid under pressure. The apparatus, known as a liquefier, used for this purpose, is illustrated in Fig. 8, which shows a typical installation. This is Elworthy's dream come true.

The liquefier consists of a heavy steel cylinder fitted with an ingeniously contrived lid which operates on the breech block principle. Heat is supplied if necessary from a steam jacket, and to firms who use fairly large quantities of carbon dioxide, the use of solid instead of liquid CO_2 offers such conveniences in handling that the liquefier has been widely adopted. One interesting point can be noted. It might be thought that the gas drawn off from the liquefier would be contaminated with air, at least, during the first few minutes. In actual practice this contamination is found to be practically negligible, and in fact the gas from the liquefier is considerably purer than that from the bottles containing liquid CO_2.

THE PLANAR FORMS OF LARGE CARBON RINGS

By Dr. H. D. K. DREW

"And he that considers how most blossoms of trees, and greatest number of flowers consist of five leaves; and therein doth rest the settled rule of Nature."—Sir Thomas Browne.

The planar C_3 and C_4 saturated rings are under considerable outwardly-directed strain, and may be *likened to flasks under pressures greater than atmos*pheric; in the C_5 ring this explosive strain has become small. On the other hand, the C_8 and higher rings tend to collapse, the direction of the strain being now inwards and the magnitude increasing continuously with the size of the ring; the higher rings are therefore comparable with flasks under varying degrees of internal vacuum. Measuring the strain, as is usual on a basis of Baeyer's strain theory, by the angle through which each valency bond has to be deflected in order to adjust the tetrahedral angles (109° 28′) of the carbon valencies to the natural angles of the various regular polygons, it is seen that the strain in the C_6 and higher rings rises from −5° 16′ to the limit of −35° 16′. In fac examination of models shows that it is scarcely possibl to *exhibit the* C_7 *and higher rings as regular polygon* devoid of re-entrant angles. Ruzicka, however, ha shown that the polymethylenes from C_7 up to abou C_{30} are very stable substances, and it has therefor *become necessary* to seek an alternative to th regular polygon as a method of representation.

The difficulty has hitherto usually been overcome b regarding the molecules as "crumpled" regular polygon occupying more than one plane, the buckling relievin the natural strain in the ring. There is no direct *evidence to show that this idea is incorrect, although it* might lead to uneconomical packing in crystals; but it is interesting to find that many of the higher rings are capable of assuming planar forms, showing beautifully *symmetrical patterns, under degrees of strain* comparable with those in the small planar rings. Such rings, moreover, are built up of combinations of the "zig-zag" and "meandering" forms of chains of carbon atoms known, on *X*-ray evidence, to exist in long-chain aliphatic substances. Open trigonal, pentagonal, hexagonal, and other units may "stroll"

FIG. 1
Zig-zag form of chains

FIG. 2
Meandering form of chains

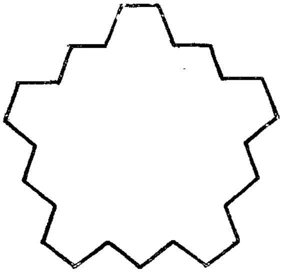
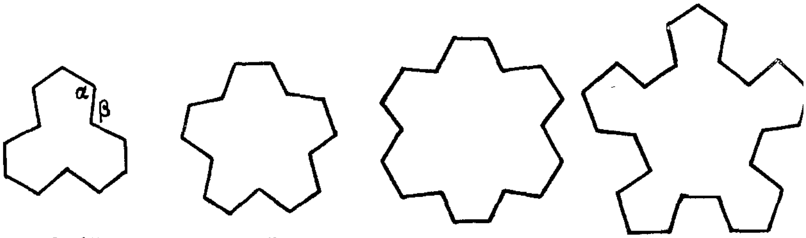


FIG. 4
Alternative ring form of C_{15}



C_{12} {α114° 44′, β104° 12′} C_{15} {α108° 58′, β109° 58′} C_{18} {α112° 58′, β105° 58′} C_{25} {α109° 10′, β109° 46′}

FIG. 3
Ring forms (drawn to uniform scale)

: und large rings and eventually close with but little rain. The rings fall into groups with total angular rain equal to that in the cyclobutane, cyclopentane, cyclohexane, and other simple plane rings; but in the ther rings the angular strain per valency bond may tually be *far less than in the corresponding small* ing, because the total strain is distributed over a reater number of bonds. The forms of planar carbon ings having axial symmetry are of great interest, for hey suggest the outlines of flowers and leaves and the figurations" of animals.

The carbon atoms in a polymethylene ring must all under the same strain. Since also they are all of he same size and are in contact successively it follows hat a geometrical figure intended to represent the nolecule of a polymethylene must have all its sides qual and all its angles equal to, or modified to the ame extent from, the tetrahedral angle. The modification from the tetrahedral angle may be in either sense, ince it is necessary to assume that the valency bonds of arbon resist distortion equally in either direction, that s to say, that a diminution of the tetrahedral angle will roduce the same strain as an equal expansion of that ngle. An important point is that some of the angles f the figure will necessarily be re-entrant angles.

The axially symmetrical figures satisfy all of these onditions and are therefore capable of representing ossible molecular forms. In general, there are two olutions for each figure: one in which all the internal i.e., salient) angles and the external angles of the e-entrant positions are equal (though in no case can hese angles be equal to the tetrahedral angle); and a econd in which each of the internal angles is diminished or increased) from the tetrahedral angle to the same *xtent as each external angle at the re-entrant positions* s increased (or diminished) from the tetrahedral angle. The second is the figure of minimal strain and is to be egarded as representing the stable form of the molecule. The first forms mentioned above have the same strain t each carbon atom as the corresponding smaller rings, hat is to say, the total strain in the larger rings is reater than that in the smaller prototypes; but the econd forms have smaller strain at each carbon atom han the corresponding smaller rings, for they have the ame total strain as these latter.

An example will make the matter clear. In the case f a C_{25} ring made up of five open pentagonal units see Fig. 3) the corresponding smaller ring is the regular pentagon. The first form of this C_{25} ring has all of the ngles, α and β, each of 108°; the second form has the ngles α each of 109° 10′ and the angles β each of 09° 46′. In this second form the strain at each carbon tom is only +18′, as against +1° 28′ in the case of he regular pentagon; the total strain, however, is that f the regular pentagon. For all axially symmetrical igures made up of open pentagonal units the relationship between the angles (measured in degrees) is given y the expression: $\beta = \frac{3\alpha}{2} + \frac{\theta}{2} - 90°$, where θ is the ngle subtended by the repeating unit at the centre of he figure (if N is the number of carbon atoms in the whole figure, then $\theta = 360° / \frac{N}{5}$). Similar expressions can be written for figures made up of other strolling units.

The modification, *k*, of the angles (α or β) from the tetrahedral angle is given by the expression:

$$n(\phi + k) + m(360° - \overline{\phi \pm k}) = N(180°) - 360°,$$

where ϕ is 109° 28′, *n* is the number of ordinary angles, and *m* the number of re-entrant angles in the figure. The expression applies to all axially symmetrical figures, giving both solutions in each case. The total strain in the ring is $-k$N; its nature is not invariably indicated by that of the strolling unit present: for example, the C_{30} ring of six pentagonal units has the total strain of the regular hexagon and not of the regular pentagon. To sum up the foregoing argument, it can be shown that the strain in the axially symmetrical rings can be distributed evenly over all of the angles without causing the rings to open or to lose their symmetry.

The higher rings which are threefold and fivefold multiples of the planar rings C_4 to C_8 inclusive, exhibit axially symmetrical forms which have the same total strain in each case as these corresponding simple rings. In the case of the rings which are multiples of five, the angular strain of each valency is exceptionally *small. It is a minimum, among rings of moderate size,* for the C_{15} and C_{25} rings; and therefore it is possible that these rings may have exceptional significance in nature.

The following table gives the strain per valency bond (regarded as evenly distributed over all the internal angles of the figure) for various axially symmetrical rings in which all the carbon atoms are in one plane:

C_4 + 9° 44′;	C_{12} +3° 14′;	C_{20} +1° 57′;
C_5 + 0° 44′;	C_{15} +0° 15′;	C_{25} +0° 9′;
C_6 − 5° 16′;	C_{18} −1° 45′;	C_{30} −1° 3′;
C_7 − 9° 33′;	C_{21} −3° 11′;	C_{35} −1° 55′;
C_8 −12° 46′;	C_{24} −4° 15′;	C_{40} −2° 33′.

With one exception, these are all forms of minimal strain. The *exception arises in the case of* C_{12}, which has also an axially symmetrical form (strain per valency −2° 38′) with the total strain of cyclohexane; this is the form of minimal strain. The C_{16} ring is represented by a form having the total strain of cyclo-octane; its strain per valency is −6° 23′. In some cases there is more than one form of ring having minimal strain, thus comparing the alternative ring forms of C_{25} (Figs. 3 and 4) it will be seen that one form is less compact than the other.

Where the atoms do not interfere, the larger rings *can be opened and themselves used as units to* build still larger rings (*e.g.*, the alternative form of the C_{25} ring will give rise to an axially symmetrical C_{125} ring with minute strain per valency). These very large rings need not be discussed, since corresponding compounds are as yet unknown; but the possibility of applying similar treatment to carbohydrate chains should not be disregarded.

The atoms engaged in the formation of large planar rings are arranged in groups in two or more concentric

rings; *e.g.*, the C_{20} ring made up of four open pentagonal units, has inner and middle rings of eight carbon atoms each and an outer ring of four carbon atoms. The valencies not engaged in the carbon-to-carbon unions are oriented in a regular manner; thus, the valencies of the inner sub-ring may all point inwards, those of the outer ring pointing outwards. In some cases free revolution of one axially symmetrical form into another having the same strain is possible; this cannot occur unless the angles α and β are equal, and thus does not apply to figures of minimal strain.

It is interesting to speculate on the nature of the directive forces which control the shapes attained by living objects and to connect them with the form of the seed molecules as at least one of the primary causes; but at present there seems to be no available mechanism to enable the shapes assumed by groups of cells during growth to be correlated in any way with those of constituent molecules.

SOUTH AFRICAN CHEMICAL BUSINESS

It is stated that the Southern Rhodesia Government has been approached by the promoters of a scheme to distil power alcohol from maize. Negotiations are proceeding with a group of London business men but difficulty has arisen over the price to be paid the grower who would have to be given a long contract. The Government has offered a duty rebate of 3d. per gal. on petrol mixed with spirit in a proportion of four gals. of petrol to one of power alcohol.

The Government Mining Engineer in Portuguese East Africa is trying to influence his Government to replace the importation of petrol by spirit manufactured locally from molasses. At the Buzi Estates near Beira spirit is being produced for private use at the rate of 2d. per litre, one litre of motor spirit being obtained from five kilograms of waste molasses. When the motor spirit is produced from cane, the cost per litre is only 3d. Cars and motor lorries on the estates have been run on this spirit for a considerable period, and have given satisfactory service. Usually 9% of benzine is added to the spirit which is known locally as "Buziline." In a comparative test it was found that for every 26 litres petrol gave 100 kilometres, but at least 31 litres of "Buziline" were required to accomplish the same distance. Thus, although consumption is 19% higher the cost is still much lower. If the price of petrol fell, this spirit could not compete with it, but it can under existing conditions. The present production of molasses is estimated to be almost sufficient to provide current motor spirit needs. With the sugar factories working at full capacity there should be an excess.

It is also noteworthy that the cane growers and wine farmers in most parts of South Africa claim that they can produce enough alcohol to manufacture solutions of 10% alcohol and 90% petrol to serve all the needs of the country. This fuel is said to be superior to imported petrol. One large sugar factory in Natal has already installed the new Richard Allenet process and after a study of this and other features of the industry, the chief technologist of the South African Sugar Cane Growers' Association has announced that from 16,000,000 to 25,000,000 gal. of pure absolute alcohol could be produced. Large quantities of molasses are rejecte annually by the sugar factories as waste, and to remov it large sums are often paid. If this waste matter ca profitably be converted into alcohol and other product as claimed, the sugar subsidy will be relieved of one of it greatest anxieties.

For over ten years an economic motor fuel has bee manufactured from local products in Natal, and som years ago, during a petrol famine, a Natal manufacture drove his car for over 40,000 miles entirely on this fue It has also passed the exacting tests of various Sout African and visiting chemists. This spirit is made fron molasses, which is brought to the factory by rail tank containing from 4000 to 5000 gal. and from these i gravitates into storage reservoirs each with a capacit of 250,000 gal. Thence the molasses is pumped to th supply tank under the roof of the main factory and ru into wash mixing vats, where water is thoroughly mixe into the molasses by means of compressed air draughts A small quantity of yeast or ferment is then brought int contact with the mixture, and at the end of 40 hours th fermentation immediately set up will be advance sufficiently for the alcohol to be run into the still. Yeas used in this factory arrives in little glass cylinders fron the Paris Pasteur Institute. The culture is seeded int yeast culture apparatus and a large quantity raised fo local needs.

In the still-room everything is disinfected wit chloride of lime to kill injurious ferments. The fermented wash containing from 6% to 8% alcohol is pumped int supply tanks, and thence through a regulating cock t the wash heater. In the analysing column which it enters next, the alcohol is removed, leaving at the bottom dunder, or refuse, free of alcohol. The alcohol has to pass through the rectifying column where the unwanted substances still remaining in it are removed. Thence the pure alcohol is run into the spirit-room for conversion into motor spirit. From there it is pumped by compressed air to the mixing room, where the proportions observed are 60% alcohol to 40% ether. Excise regulations demand the addition of 4% benzol, 2% wood naphtha, ½% pyridine, with a small quantity of ammonia gas blown through. Colour is obtained by the addition of methyl violet.

This factory covers an area of nearly 80 acres, with the business site spread over about 20 acres. It manufactures fats, oils, and other substances and has carried out useful experiments with fertilizers.

With a capital of £15,000, the Vergelegen Shale Oil & Mineral Co., Ltd. was floated with the idea of extracting oil from some of South Africa's coal. This company was to spend about £10,000 on machinery and plant and would first work the extensive oil shale deposits near Underberg, Natal. Geologists have traced the rich Natal deposits for over 200 miles, and operators thus have a profitable field to work. So far only small quantities of this shale have been quarried for experimental purposes. The chairman of the board of directors has said that his company could compete with imported oil without the help of protection or subsidy. The Scottish machinery to be used is estimated to distil 80 tons of shale daily, which represent a yield of 2400 gal. of crude oil.

In the near future the manufacture of oil from eucalyptus trees may be carried on extensively in South Africa, for the Union has many extensive eucalyptus plantations, and they are on the increase. Some of the timber is felled for various purposes, but no attempt has been made to extract the valuable oils in the foliage. A good deal of rich foliage is also obtained when the forests are cleared of coppice growth and the stumps are cleared. All this waste material could be used to provide oil. This question, however, has not escaped official attention, and the necessary investigations have been initiated by the Chief Conservator of Forests and the Director of Native Agriculture. These officials were eager to discover how such oils would compare with Australian oils, and what the general yield and quality would be. The first investigations were made in the Natal Native Forest Plantation at Zwartkop, but later on leaves were obtained from many parts of the Union and submitted to careful test. In this way it has been possible to test all varieties of leaves and to determine the geographic influence upon quality. When the leaves had been tested by qualified chemists, an official report on the investigation was published.

According to this report a good yield of excellent quality oils can be produced from leaves of South African eucalyptus. Both as regards yield and quality, South African oils compare favourably with oils produced from corresponding Australian species. Each type of oil contains one or more constituents principally responsible for its market value. For concentrating these desirable constituents and at the same time removing those not required, the crude oil must be subjected to fractional distillation. Because of an overproduction of eucalyptus oil the market price is at present very low—practically unremunerative.

At present South Africa has only one small establishment producing eucalyptus oils, and some of these oils are being used by the mines in their oil flotation processes, and more such oils could be made for local consumption. In an average year South Africa imports nearly 3000 gal. of eucalyptus oil, mostly from Australia. A very small quantity of this oil is bought for oil flotation purposes.

For the last few years a fair quantity of lavender water and other scents has been manufactured in a Port Elizabeth factory and retailed in pleasing containers. The extensive manufacture of lavender water in South Africa, however, is still a hope of the future. Some eight years ago experimental plantings of lavender were made at the National Botanical Gardens at Kirstenbosch; for the next seven years little success attended the venture, but the director, convinced that there was a future for lavender in South Africa, continued his experiments. In 1930 it was possible to distil a small quantity of lavender oil from one of the crops and send it to the Imperial Institute for report.

In the past the main obstacle to the production of lavender was selection of the right types of seed. Seed from several countries had to be tried before that most suited to the South African climate was found. During the last four years botanists have been receiving parcels of seed from France and the Kew Gardens, and most of this seed has been found well adapted to the country.

THE NATIONAL PHYSICAL LABORATORY

The inspection by the General Board of the National Physical Laboratory, Teddington, was held on June 27, and a large number of distinguished visitors were received by Sir F. Gowland Hopkins, P.R.S., chairman of the Board, Lord Rayleigh, F.R.S., chairman of the Executive Committee and Sir Joseph Petavel, director of the Laboratory. After the reception the visitors were able to go through the buildings of the Laboratory and to see the important work in progress in the various departments dealing with aerodynamics, engineering, metallurgy, physics, and electricity.

In the engineering department testing equipment alone, although forming only a section of the many exhibits, was of considerable interest, including tests to destruction of materials, fatigue-testing machines, etc. Other exhibits showed fatigue and impact tests on spring steels and high-tensile forgings to determine the effect of surface conditions on fatigue strength, the experimental work on corrosion-fatigue, research on the resistance of welds and weld metals to repeated loading, abrasion-testing machines, and an explosion vessel and apparatus for the determination of specific heats of gases at high temperatures. In the Road Laboratory methods and machines used in laboratory tests on road stones were to be seen. Of particular interest were the exhibits dealing with high-speed air-flow. High-speed air injectors are now used in many industrial processes; apparatus has now been developed for the investigation of the induction effect, and for the production of shadowgraphs showing the air-flow in the region of the jet. The Laboratory has recently developed an open-jet induced wind tunnel for air speeds up to 1000 m.p.h.

The metallurgy department attracted many visitors, who were able to see the work on impurities of copper undertaken for the British Non-Ferrous Metals Research Association. In another room the refractory apparatus developed by the Laboratory for research at high temperatures was on view, and equipment was shown for *X*-ray studies of metals, spectroscopic analysis, and apparatus for investigating crystal structure by diffraction of a beam of electrons. The chemical exhibits showed methods of microchemical analysis, and means for determining inclusions in steel, solubility of gases in pure iron using a molybdenum-wound resistance furnace, and solubility of hydrogen in aluminium.

Many visitors naturally wished to see the new ship tank opened in November last in the William Froude Laboratory, and during the inspection a model ship was towed along the tank, the resistance and speed being automatically measured. Many other exhibits of equal interest were seen in this laboratory and in the aerodynamics department, where work of considerable benefit to aircraft is being pursued.

It has been possible here to mention only a few of the exhibits. With more than seven hundred others to be seen in many excellent buildings, visitors could have had little doubt that here was one of the finest-equipped research centres in the world.

PULVERIZED-FUEL MARKETING SCHEME

An announcement of considerable interest and importance, both to the coal industry and to fuel consumers in this country, is made by Messrs. H. Tollemache & Co., Ltd. As the result of a steadily increasing demand for the supply of coal in pulverized form, this firm has recently decided to embark on the production of pulverized fuel for marketing purposes, and a first plant is now being erected at a colliery in Yorkshire which, it is anticipated, will be in production in July.

In order to appreciate the significance of this announcement, it must be realized that this is the first practical step yet made to bring this country into line with Germany and the U.S.A., where for some years past pulverized fuel in prepared form has been readily available for purchase by consumers.

The advantages of pulverized coal firing are well known to all those who have followed modern developments in the art of burning coal. This form of firing enables coal to be used with all the advantages of convenience, heat control, and efficient combustion, that are possible with oil and gas firing, but at a far lower price per heat unit to the consumer. Up to the present in Great Britain, those consumers who have wished to avail themselves of these benefits have been obliged to install the necessary coal-grinding plant to produce their requirements of powdered coal on site. Although the cost of pulverized fuel-firing equipment compares favourably with oil and gas installations, the additional expense of providing coal-preparation plant, together with the extra space and attention involved, has undoubtedly retarded the more general adoption of this form of firing, in spite of the improved operating results to be obtained.

Many industries are consequently still using old-fashioned and out-of-date methods of fuel consumption, and the majority of metallurgical furnaces in this country are still operating under hand-firing, with all the resulting difficulties of obtaining accurate control of furnace conditions. The development of the marketing scheme now announced should therefore give a welcome impetus to the modernization of works and factories in this country.

In Germany and America many industries have grown up, based upon the centralized production of pulverized coal and its distribution in that form to consumers. For several years past, large concerns in those countries have been deriving their heat requirements solely from pulverized fuel prepared at the mines and delivered direct to their works. The consumer who uses pulverized coal in prepared form will benefit not only by the savings in the capital expenditure on his own plant but also by the fact that the production cost of pulverized coal becomes greatly reduced as the output increases, so that the most economical production is obtained by the preparation of large quantities in bulk. The cost of pulverized coal produced in a central plant for a group of consumers will therefore be considerably lower than could be obtained if the latter were to purchase raw coal and pulverize it themselves at their own works.

A special advantage which will be derived in this country by the marketing of pulverized coal will be that works desiring to investigate this method of firing will be able to do so for the small expense of converting a single furnace or boiler, and for this purpose Messrs. H. Tollemache & Co., Ltd., propose to supply samples of pulverized fuel for trial purposes packed in special waterproof paper bags. For regular consumption however the fuel will be distributed in specially designed tank wagons from which the pulverized coal will be discharged by pipe line into the consumer's bunker, with all the simplicity, convenience, and cleanliness of fuel oil.

This scheme is particularly opportune in Great Britain at the present time in view of the tax which has now been imposed on heavy oil. In order that the coal industry may reap the fullest possible benefit from this tax, it is obviously essential that fuel oil users should be able to convert back to coal, without loss of efficiency and with the minimum of capital expenditure. Both of these requirements are satisfied by the pulverized coal marketing scheme, which will thus prove of no less benefit in assisting oil consumers to return to coal than in encouraging coal consumers to replace obsolete methods of firing by a modern and efficient process.

It has therefore been felt that the supply of pulverized coal in prepared form will meet a very real need of British industry. Pulverized coal is the cheapest source of accurately controlled heat, and in these days increased efficiency is the principal means of reducing production costs. The availability of pulverized coal as a marketable commodity therefore constitutes a definite milestone in the industrial progress of this country and will be welcomed both by manufacturers in their struggle to expand their markets and by the coal industry in its fight to extend the utilization of coal and its supply in a form to suit modern needs.

BENNETT SONS & SHEARS, LTD.

Tyseley, on the outskirts of Birmingham, is the home of many firms whose products are famous. On visiting the area one sees the outstanding landmark of the Bakelite works shaft, and passes many names that have become household words in industry. In the midst of this notable group of factories is the Farringdon works of Bennett Sons & Shears, a firm established 120 years ago, and now one of the leading manufacturers of special plant for chemical and pharmaceutical works and laboratories. Many of its productions are made largely of sheet metal, and the firm has paid much attention during the last few years to the advance in welding practice, so that a visit to the works, such as we paid recently in company with the manager, enables one to see many of the most up-to date processes in operation.

The firm prides itself on being particularly self contained, the various parts for most of its production being made on the spot. This must always have been its policy, for even the bricks with which the factory was built were made from clay dug from the soil on which the works now stand. The buildings themselves, many of them of recent construction, are of excellent design as can be well appreciated from the accompanying illustrations. A foundry is often a place of such gloom that its grime and haphazardness remain hidden unti

the cupola casts a temporary glow, but here it is bright and airy, giving the moulders every facility for good workmanship in the deft touches of "striking out" and moulding from patterns. The two large bays of the engineering shop are also remarkably well ordered and well lighted, and there is in operation one of the best systems we have yet seen for issuing tools and materials to workmen, the stock-room having almost the neatness of lay-out of a library. In the engineering bays are machined and polished many of the parts used in the construction of steam-jacketed pans, mixing vessels, ointment mills, powder sifters, tablet machines, etc. and stills for many distillation purposes. Here we can only mention a few of the firm's products, and it need only be said that it has made a speciality of the chemical manufacturers' requirements, and has studied the needs of the brewer, the manufacturer concerned with food processing, and many other industrialists operating special processes.

The foundry of the Farringdon works

Welding has lately changed for the better much of the plant used in industry, improving not only the lay-out and appearance of apparatus, but ensuring better jointing of parts than was possible with the older riveted unions. Notable advances have been made in the last few years with the welding of non-ferrous metals, and Bennett Sons & Shears have kept pace with these developments. One of the most interesting parts of the works is that in which large aluminium tanks, brewing coppers, etc. are manufactured from the sheet metal. Autogenous welding has provided a means of jointing aluminium sheet with complete assurance of homogeneous results but the technique of the process is mastered only after considerable experience. A welding rod of pure aluminium is used, so that the joints contain no other metal, and the invisible film of oxide on the metal is removed with a flux which is applied with the melting rod, so that it is fed on to the weld at the position where it is immediately required. We were able to watch the manufacture of some large aluminium tanks, from the first pressing of the sheets to the correct size and shape, the chamfering of the edges to be welded, and the shaping of a "lip" around the top of the tank by folding the sheet round a square-sectioned iron rod and then welding the fold to the sheet, to the actual jointing of the corners of the tank by welding, the trimming and smoothing of the welds, and the final process of burnishing the whole tank.

Bennett Sons & Shears have made a speciality of sheet copper work and the products are well known in many works and laboratories that are concerned with the rectification of ether and benzol, the distillation of essential oils, concentration of food products, etc., copper having proved itself the most suitable metal for stills, evaporating pans, and similar plant. The copper welding which is now done at the works gives a much neater appearance than the old method of brazing a zig-zag union. In other parts of the works we were able to see brass and gun-metal castings being made and afterwards smoothed in the sandblast and finally given their bright finish with the polishing brushes. The firm is associated at the Farringdon works with H. Pontifex & Sons, which has specialized in the production of ammonia-compression refrigerating plant, beer chillers, and bottling and carbonating plant, whilst an interesting production is a pasteurizing plant, in which bottles of milk are passed slowly through a steel tank to become heated slowly to the pasteurizing temperature and retained at this temperature for twenty minutes. Thus, the two firms together have made the Farringdon works the starting point of many industries in this country.

Steam coils, pulp washers, tanks, etc. in course of manufacture

CANADIAN MINING

Eight firms were engaged in Canada in 1931 in producing natural abrasives, including corundum, diatomite, grindstones, pulpstones and scythestones, and volcanic dust. These firms had invested $1,310,108 and produced products valued at $73,452. Manufactures of artificial abrasives and abrasive producst were worth $4,857,914. Products turned out were fused alumina, crude silicon carbide, and abrasive wheels. Other products of lesser value included refractories, ferrosilicon, abrasive cloths and papers, sharpening stones and files, artificial pulpstones, tiles, and magnesia.

SOCIETY OF CHEMICAL INDUSTRY

OFFICIAL NOTICES

Annual Meeting. Newcastle, July 10-14. To-day *is officially the last day for posting applications for participation in the Meeting. The hon. secretary, Mr. J. W. Craggs, 4, St. Nicholas Buildings, Newcastle-on-Tyne, has kindly consented to give consideration to applications which are posted at the week-end and reach him on Monday.* It is very desirable to avoid correspondence, if possible, at this busy time.

Plastics Group.—It is with regret that we announce that Prof. Rassow, of Leipzig, finds himself at the last moment unable to attend the meeting in Newcastle. It will not disappoint members, however, to learn that Dr. Herbert Levinstein has accepted the invitation to read a paper on "Phenol and Cellulose Supplies—a Survey." The subject is one of immediate importance to the progress of plastics application. In spite of the short time available we may expect it to be compiled with Dr. Levinstein's usual care, and to be written in his peculiarly refreshing style.

Advance copies of papers.—It is hoped to distribute advance copies of the papers by post to all members of the groups concerned, except those of the Plastics Group. A copy will also be available to every other member attending the Annual Meeting at Newcastle-on-Tyne on his arrival. Any member attending the conference who would like a copy earlier than is indicated above should apply to the General Secretary, 46, Finsbury Square, London, E.C.2.

Chemical Engineering Group.—Dr. S. L. Pearce wishes it known that the paper to be read before the Group and other members on Tuesday, July 11, at 2.30 p.m., has been written in collaboration with his colleagues: G. W. Hewson, F.I.C., A. L. Pollitt, M.I.Mech.E. and R. L. Rees, M.A., A.I.C.

Friday, July 14. Additional Works Visit.—A long-standing invitation issued to the Plastics Group to visit the works of the Yorkshire Tar Distillers, Ltd., Stourton, Leeds, has been extended by the directors to any member of the Society, whether visiting Newcastle or not. No one, however, should make the visit who is engaged in similar manufacture. The Newcastle party will arrive at Leeds (New Station) at 12.53, when they will be joined by the remainder, and all will proceed to the works for lunch by kind invitation of the directors. Applications should be made directly to Mr. A. Lowe, Messrs. Bakelite Ltd., 68, Victoria Street, S.W.1.

Local Addresses. Members attending the meeting but staying at private local addresses are requested to send Mr. Craggs particulars of the latter.

Billingham visit. Members wishing to return home direct from Billingham on the Friday can obtain particulars of arrangements made for their benefit and of train services generally on personal application to the Society's office at Armstrong College.

CORRESPONDENCE

UNSHRINKABLE WOOLLEN GOODS

SIR,—I was particularly interested to read the paper by S. R. Trotman in the June 2 number of the JOURNAL on the use of aqueous solutions of chlorine and bromine for the production of an unshrinkable finish on wool. It is, I think, a matter of interest to place on record that experiments on the lines of those made by Mr. Trotman on the use of chlorine and bromine solutions for rendering wool unshrinkable were made on quite a large scale in the Paisley works of the Seedhill Finishing Co. Ltd., as far back as 1914, by Mr. James Ross, managing director of that firm, and the writer.

In the case of the chlorine experiments the chlorine was piped by glass tubes from a cylinder of liquid chlorine to the treatment vessel and allowed to bubble in at a pre-determined rate. It is interesting to note that at that time we had very considerable trouble in obtaining liquid chlorine in small cylinders and we had in fact to obtain supplies from Germany. As the woollen pieces ran through the chlorine water samples were taken at regular intervals from the treatment vessel and the active chlorine determined and also the cloth was marked so that a correlation could be made between the unshrinkable effect and the chlorine content at the moment the woollen pieces was passing through the bath. In the case of the bromine experiments the bromine was converted into a saturated solution in the stock tank, an excess of liquid bromine being kept on the bottom of the vessel to ensure saturation and the saturated solution piped off to the treatment vessel and suitably diluted. The non-shrinking effect was compared with that given by the standard unshrinkable finish known as the Rosslain finish of the Seedhill Finishing Co., which was at that time, and I believe still is, regarded as a very high standard of unshrinkability, the pieces for comparison being well milled under the standard conditions in a soap bath and the shrinkage and also the effect on the white and coloured parts of the material being observed. The experiments were continued over a considerable time but were necessarily given up at the outbreak of war and as far as I know they have not been continued. The results were very much on the lines of those indicated by Mr. Trotman, namely an excellent degree of unshrinkability was obtained both with chlorine and bromine and there was considerable improvement in the handle of the woollen goods.

I am, Sir, etc.,

T. CALLAN

Hexagon House,
Blackley, Manchester
June 23, 1933

A COLLOID CORRELATION PRINCIPLE

SIR,—Reverting to my communication in your issue of April 28, pp. 372—3, on the above subject, from *Smoke*[1] it is gathered: (*a*) that the coagulated agglomerates of typical smokes are loosely attached individual particles interspersed with air or gas; (*b*) that the

[1] Whytlaw-Gray and Patterson: Arnold; 1932.

ective density of aggregates is often less than that of e separate individual particles; and (c) that the ective velocity of settling of such relatively large gregates *is similar to that of the individual separate* rticles. Other conclusions drawn therefrom by the riter can be added, viz.:

(1) Solid smoke systems originating as two-phase rosols, *i.e.*, Phase A (gaseous dispersion medium), hase B (solid disperse phase), gradually and increasingly ecome three-phase systems, *i.e.*, Phase A (gaseous spersion *medium*), *twofold* Phase BA (*solid*-gaseous isperse phase). That is, a subsidiary colloid system, f solid dispersion medium and gaseous disperse phase, formed within the original aerosol, the grown original isperse-phase particles being the new dispersion medium.

(2) The colloidal aggregates, since of similar or less ffective fall velocity and density to the component ndividual particles, will obey the law applying to ettling of the individual particles (say, $< 10^{-4}$ cm. adius), *i.e.*, Cunningham's law.

In aerosols, the principle (*cf.* Chem. and Ind., pril 28, 1933, pp. 372—3) suggests that since solid articles can grow in opposed directions though dispersed n the same gaseous medium, different laws must regulate he opposed operations. In fact, that decreasing rowth is phenomenal, since in all other colloid systems ncreasing growth occurs. But the above conclusions nake *it evident that the correlation principle* necessiates that systems of opposite growth really obey the ame laws. This apparent anomaly comes from possible aried modes of *increasing growth function*. In smoke ystems one would be the exact reversal of growth ecrease in dust systems. Fine particles would aggreate in so condensed and compacted a way that discrete *arger particles of proportionately greater density and* all velocity would be evolved. Aggregates wonld have he same packing of particles as exists in a larger dust nit *before being degraded to smaller ones*. *Another* actually occurring) would be for small particles to unite nuch more loosely with enclosed gas spaces, to form isibly larger aggregates. The former mode gives a liscrete large individual particle (like a large dust "particle"), the latter possible (and actual) mode a ewly-formed colloid system. The responsibility of this *econd mode new colloid system is an increasing size* ffect (conferring widest possible scope of life tendency) beying the same laws as units formed by the decreasing ffect, for if discrete compact enlargement occurred in mokes, particles would obey Cunningham's law, Stokes' law, the ordinary gravitational law, with uccessive size increase, as in dust systems they will bey *those laws in reverse order. Smokes and dusts* vould be the respective complete counterparts of a undamentally reverse operation—not merely in regard o direction of growth. Smokes (solid) would aggregate s though completely reinstating the energy dissipated n parallel natural dust degradation. Seemingly contraictory of the second law of thermodynamics, that it loes not occur suggests an *entropy of natural colloid* ystems.

Consider (*a*) a smoke agglomerate increasingly grown o $> 10^{-2}$ cm. radius, and (*b*) *a dust particle decreasingly* rown to $> 10^{-2}$ cm. radius. The smoke agglomerate being itself a colloid system, and the dust particle being discrete, the former is likely to have the effective density and fall velocity of Stokes' law (for particles say, $< 10^{-2}$ *cm. radius*), *though from mere size consideration* it should, as is the dust particle, be referable to the normal gravitational law. Whilst, therefore, dust particles may, according to size, obey either (*a*) Newton's law, (*b*) Stokes' law, or (*c*) Cunningham's law, smoke particles are likely to obey only either (*b*) Stokes' law or (*c*) Cunningham's law. Since each imposes a different settling rate, the *two smaller-sized components* of atmospheric dust will be augmented by smoke particles, but those smoke particles which keep pace in density (hence velocity) with very much smaller dust particles obeying Stokes' law will, at the same time, accord in size with the largest dust particles obeying Newton's law—themselves never augmented by smoke particles in regard to settling velocity.

The operation of the principle is therefore due to the irreversible nature (thermodynamically) of natural dust *degradations as dispersions, formulating increasing* growth of smoke particles as embryo colloid systems rather than as discrete enlarging particles. The underlying cause of selective embryo colloid growth (inside original smoke) is evidently the entropy of matter in dust form. The dissipation of less potential energy in unit time (falling under Stokes' law) by a large smoke agglomerate as compared with possible dissipation if such agglomerate were discrete (dust degradation being reversible) represents the difference in energy levels. *The application of Cunningham's modification of Stokes'* law, viz., $\left(1 + A\frac{\lambda}{r}\right)^{-1}$ [where λ = mean free path of dispersion molecules, r = particle radius (when $< 10^{-4}$ *cm. radius*), *and* A = *constant for given dimensions*], and Svedberg's relationship suggest that mobility of initial particles under dispersion medium molecular bombardment *initiates* selection *of* embryo colloid formation rather than discrete growth, which would be analogous in form to crystal growth in enclosed solutions.

The possibility of both increasing and opposed decreasing size growth in aerosols is therefore not really phenomenal since expressing second law of thermodynamics operation, though increasing growth to *discrete particles would seemingly be so in an unenclosed* natural system establishing total energy reversibly, and opposing the second law.

Combining Halley's law (governing number of dispersion medium molecules with height), Stokes' law, and Cunningham's law, the atmosphere is likely to hold three different classes of particles (not strictly delimited), of (*a*) *rapid accelerated velocity under gravity*, (*b*) slow, non-accelerated velocity under Stokes' law, and (*c*) decelerated velocity less than (*b*) under Cunningham's law. Owing to the different atmospheric amplitudes implied, the respective particles will confront and collide. This may be one manner in which disintegration occurs in nature in that continuous, neglected, realm, probably co-extensive with the atmosphere—in it, but not of it—which, more than worthy of a distinctive title, one would feel appropriately styled the Staubosphere.

I am, Sir, etc.,

Sheffield, June 19, 1933 S. C. Blacktin

PERSONAL AND OTHER ITEMS

The Governing Body of the Imperial College of Science and Technology has elected the following old students of the College to Fellowships:—Emeritus Professor Henry Louis, a past president of this Society; Emeritus Professor P. F. Frankland, F.R.S., past president of the Institute of Chemistry and of the Chemical Society; Sir Basil Mott, F.R.S., the noted consulting engineer and mineralogist; and Dr. A. E. H. Tutton, past president of the Mineralogical Society, and well-known for his work on crystalline structure and chemical constitution.

Prof. R. Robinson, F.R.S., has been elected an honorary member of the Kaiserlich Leopold Deutsche Akademie der Naturforscher, Halle.

Sir Richard Gregory, Bart., Emeritus Professor of Astronomy, Queen's College, London, editor of *Nature* since 1919, has been elected a Fellow of the Royal Society.

The University of Leeds has appointed Mr. A. T. King to the chair of Textile Chemistry. Mr. King, who is chief chemist of the Wool Industries Research Association, is to read one of the papers at the Session of the Chemical Engineering Group at Newcastle.

Prof. L. N. G. Filon, F.R.S., has been re-elected Vice-chancellor of the University of London.

The President of the Board of Education has appointed Brigadier E. E. B. Mackintosh to be director and secretary of the Science Museum in succession to Sir Henry Lyons, F.R.S., who is retiring in October next after having held the post for twelve years.

Armstrong College New Hall

New Hall, the men's hostel at Cochrane Park, Benton, adjoining the playing fields of Armstrong College, will certainly be new to most members of the Society attending the annual meeting, since it was opened only at the end of last year. The building has a fine appearance, being built on three sides of a quadrangle, whilst inside the "houses" the rooms are arranged around the staircases in the style of the older universities, and are spacious and very comfortably fitted up. The dining hall is finely panelled and well lighted.

Dr. A. A. Hall, the warden, and a Newcastle member, will be in residence during the annual meeting, and guests are assured of an excellent welcome.

University of London

On June 26 the scheme which is to provide the University of London with a central home was officially begun when the King, accompanied by the Queen, laid the foundation stone of the new buildings in Bloomsbury. Their Majesties were received by the Earl of Athlone, Chancellor of the University, and the ceremony was carried out in the presence of a distinguished gathering of the representatives of British and foreign universities.

The project for a central building has been under consideration for the last twenty years. The Bloomsbury site covers 10½ acres, is centrally situated, and is in every respect ideal for its purpose. The building has been designed by Mr. Charles Holden.

Correction

On line 7 of the second column of p. 484 of last week's issue of CHEMISTRY & INDUSTRY, "2:3-dimethyl erythronamide" should read "3:4-dimethyl 1-erythronamide."

MARKET REPORT

This Market Report is compiled from special information received from the manufacturers concerned.

Unless otherwise stated, the prices quoted below cover fair quantities net and naked at sellers' works.

The following alterations in prices are reported since the publication of the last Market Report (cf. CHEM. & IND. June 9, 1933, p. 489).

TAR PRODUCTS

Pitch, medium, soft.—80s. per ton, in bulk at makers' works.

Pyridine.—90/140—4s.—4s. 6d. per gal.; 90/180—2s.—2s. 3d. per gal.

Xylol.—1s. 11d.—2s. per gal. Pure, 2s. 2d.—2s. 3d.

PHARMACEUTICAL AND PHOTOGRAPHIC MATERIALS

Iron Ammon. Citrate.—B.P.—1s. 9d. per lb. for 28-lb. lots. Green, 2s. 5d. per lb. (list price).

Potass. Citrate.—B.P., 1s. 7d. per lb. for 28-lb. lots.

Sod. Citrate, B.P.C., 1911.—1s. 4d. per lb. B.P.C., 1932, and U.S.P.—1s. 8d. per lb. for 28-lb. lots.

PATENT LIST

The following is a list of complete specifications of chemical interest which are open for inspection under Section 91 (4) (a) of the Patent Acts. Printed copies are not available, but photographic copies may be obtained at a charge of 8d. per page (minimum 1s.) from the Patent Office, Chancery Lane, W.C.2.

I. 33,465 (1932). *Cooymans. See* IX.

34,700 (1932). Soc. Anon. d'Ougrée-Marihaye. Regulating fineness of products of grinding machines.

II. 34,681 (1932). Still. Coke ovens.

34,788—9 (1932). Standard Oil Development Co. Solid fuels.

III. 31,641 (1932). Bamag–Meguin A.-G. Production of lactic acid and its salts.

33,136 (1932). Carbide and Carbon Chemicals Corp. Mixed esters.

34,508 (1932). Blumer. Producing high-grade condensation products.

35,000 (1932). I. G. Farbenind. Manufacture of dihydroxyfluoranthene and the dialkyl ethers thereof.

V. 33,922 (1932). Golwig. Removing fatty and pitchy matters from animal fibres and making them more readily feltable.

34,679 (1932). I. G. Farbenind. *See* XIII.

VI. 34,678 (1932). 9493 (1933). I. G. Farbenind. Dyeing animal fibres with metal complex compounds of organic acid dyestuffs.

VII. 28,600 (1932). Bacon. Recovery of sulphur.

31,641 (1932). Bamag–Meguin A.-G. *See* III.

IX. 33,465 (1932). Cooymans. Treating slurry in rotary kilns for cement and similar manufactures.

X. 32,012 (1932). Electro Metallurgical Co. Alloy steels.

34,870 (1932). Budowski and Bardt. Hardening of iron and steel.

35,016 (1932). Mond Nickel Co. Annealing alloys.

35,166 (1932). Bats. Alloys.

XI. 33,777 (1932). Igranic Electric Co. Production of electron-emission-increasing material.

XIII. 34,679 (1932). I. G. Farbenind. Manufacture of sheets or films from artificial polymerization products.

34,988—90 (1932). Rosenblum. Production of oil-soluble resins.

XIV. 34,852 (1932). Soc. Anon. des Etabl. Hutchinson. Imitation of natural creases on indiarubber articles.

…X. 34,780 (1932). Serailian. Apparatus for concen-…ing fruit juices.

…5,183 (1932). California Fruit Growers Exchange. …serving fruit juices.

XX. 30,763 (1932). I. G. Farbenind. Manufacture of …seno compounds.

XXI. 34,893 (1932). Kalle & Co. Preparation of tanned p…tures.

…4,996 (1932). Gaspar. Producing photographic dye-…uff images.

35,188 (1932). Dürkoppwerke. Producing pure whites and a pure yellow in screeued photographic pictures.

GENERAL NOTES

Official Trade Intelligence

The Department of Overseas Trade (Development and Intelligence), 35, Old Queen Street, London, S.W.1, has received the following inquiries for British goods. British firms may obtain further information by applying to the Department and stating the specific number. *Argentina and Uruguay:* Hardware, steel (878). *British India:* Paint, varnish, etc., heavy chemicals (854). *Mexico:* Aniline colours and chemical products used in the textile, tanning, rubber, match, and soap industries (879). *Panama:* Structural iron and steel (G.Y. 12,716). *Portugal:* Steel, tinplate (869). *South Africa:* Aniline dyes (860).

Import Duties Advisory Committee

The Import Duties Advisory Committee gives notice that it has under consideration an application for increases in the import duties on wrought cased tubes of iron or steel; plates, sheets, strip, wire, rods, sections, and tubes of brass and alloys of copper, other than nickel alloys; plates, sheets, strip, rods (other than wire rods), sections, wire, and tubes (but not including tube shells) of copper; plates, sheets, and wrought forms of nickel; ingots, billets, and wrought forms of nickel alloys, other than those containing 60% or more of nickel; rolled sheets, prepared for use in printing and engraving, strip and wire of zinc. Any representations in regard to this application should be addressed to the Secretary, Import Duties Advisory Committee, Caxton House, Tothill Street, Westminster, London, S.W.1, not later than July 17, 1933.

New I.C.I. Dyestuffs

Three attractive additions to the Caledon range of dyestuffs have recently been announced by Imperial Chemical Industries, Ltd., namely, Caledon Brown 2 GS and 5 GS and Caledon Yellow Brown 3 GS, which are suitable for application to natural silk and viscose artificial silk as well as linen and all types of cotton materials. All possess the excellent fastness properties usually associated with the Caledon series, and their very good fastness to light makes them eminently suitable for the dyeing of curtain materials etc.

An addition to the Dispersol range, Dispersol Fast Brown 4 RS, is of interest for dyeing all forms of acetate silk, and its rich red-brown shade is of value where good all-round fastness is desired, giving excellent level results on yarns or piece goods. It can be used in conjunction with other dyestuffs for application to mixed fabrics containing acetate silk, as it is unaffected by acids, alkalis, and salts that may be necessary in the dye bath.

Nickel Alloys

An attractive leaflet (A. 18) recently issued by the Mond Nickel Co. shows a number of examples of the desirable qualities which are obtained economically by the nickel case-hardening process. A number of motor manufacturers, notably Morris Motors Ltd., Rolls Royce Ltd., Leyland Motors Ltd., and Associated Equipment Ltd., employ the process for gears, and it has been found very useful for many parts of aero engines, locomotive parts, heavy-duty roller-chains, coal-cutting machines, etc. The booklet provides a concise description of the process, and its advantages.

A second leaflet (B. 14) entitled "The Manufacture and Physical Properties of Nickel-Copper-Chromium Austinitic Cast Irons," describes the manufacture and use of "Ni-Resist" and Monel metal. Some interesting micro-photographs are included.

Lecithin

A new booklet entitled "Emulgo—The World's Standard Lecithin," has recently been issued by Fred.k Boehm Ltd., 17, Jewry Street, London, E.C.3, and should be of interest and use to those concerned with the chocolate, confectionery, and bakery trades. "Emulgo" is a vegetable lecithin prepared from the soya bean, and when used in very small amounts improves chocolate not only for handling in the plant, but also in appearance and taste. Coatings in which the lecithin is used are more flexible and can be worked at lower temperatures than normally, whilst it adds to the ease with which chocolate mouldings may be made.

The Lovibond Comparator

In response to repeated requests for permanent colour standards for p_H determinations, The Tintometer Ltd., of Milford, Salisbury, has co-operated with The British Drug Houses Ltd. in the production of a handy form of comparator in which the colour produced on the addition of a measured quantity of indicator to the liquid under examination is compared with permanent colours prepared with the well-known Lovibond glasses. These colour slides have been established by very careful comparison with solutions of known p_H and B.D.H. Indicators. While the manufacturers do not claim that the colours are in every case an exact match of the indicator colours, owing to the brightness of some of the latter, yet they are sufficiently close matches to enable correct identification of the various p_H values to be made. The Lovibond Comparator is in a handy compact form, which can be easily carried about. The standard colour glasses are fitted into a bakelite disc, which is rotated to provide colour comparison with a test-tube of the liquid being tested. Colour discs standardized on B.D.H. indicators are available for bromo-phenol blue, bromo-cresol green, bromo-cresol purple, hromo-thymol blue, phenol red, cresol red, thymol blue, and the B.D.H. universal indicator.

PUBLICATIONS RECEIVED

ANNUAL REPORT OF THE IMPERIAL INSTITUTE FOR 1932. By the Director, Lt.-Gen. Sir Wm. Furse, K.C.B., D.S.O. Pp. 55. London: Imperial Institute. 2s.

SPECTROSCOPY IN SCIENCE AND INDUSTRY. By S. Judd Lewis, D.Sc., F.I.C. Pp. vi + 94. London: Blackie & Son, 1933. 3s. 6d.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1932.

EXPENDITURE.

1931 £ s. d.	1931 £ s. d.		1932 £ s. d.	1932 £ s. d.
		To "*Chemistry & Industry*" and "*Transactions*"		
1,492 10 0		Editor's and Assistants' Salaries	1,417 1 7	
168 18 3		Sundry Expenses	164 10 7	
286 10 9		Contributors	278 5 5	
3,349 5 7		Publishing	3,230 6 1	
678 11 10		Paper	642 9 2	
58 10 2		Index	47 13 4	
	6,034 6 7			5,789 6 2
		,, *Advertisement Department Expenses*—		
1,193 11 6		Salaries and Commission	1,126 17 2	
237 11 2		Sundry Expenses	246 17 0	
66 9 6		Travelling Expenses	135 5 8	
50 6 8		Bad Debt Reserve	27 6 1	
18 0 0		Loss on Sale of Motor Car (in lieu of Depreciation)	14 0 0	
1,861 13 8		Publishing	1,868 18 3	
418 1 2		Paper	398 14 0	
	3,840 13 8			3,817 18 2
		,, *Bureau of Chemical Abstracts*—		
1,027 19 5		Salaries	1,080 13 10	
1,060 19 1		Abstractors' Fees	1,049 15 11	
138 5 3		Sundry Expenses (Patent Specifications, postages, printing, etc.): *see* Bureau a/c's.	199 5 9	
1,143 0 10		Index	984 4 3	
347 1 5		Paper	397 10 10	
2,127 7 6		Publishing	2,091 12 8	
500 0 0		(Reserve for Decennial Index, 1923—32)	—	
	5,344 13 6			5,803 3 3
	1,609 12 6	,, Postages		1,421 5 7
	23 3 9	,, Insurance of Stock		23 3 9
	17,852 10 0	,, TOTAL COST OF JOURNAL		16,845 16 11
	19 3 6	,, Purchase of S.C.I. Journals		19 3 3
	150 0 0	,, Chemical Engineering Group Printing Grant		150 0 0
		,, Sectional and Group Expenses—		
50 0 0		London	100 0 0	
100 0 0		New York	150 0 0	
75 0 0		Birmingham	75 0 0	
40 0 0		Bristol	40 0 0	
50 0 0		Newcastle	25 0 0	
60 0 0		Nottingham	—	
95 0 0		Manchester	125 0 0	
60 0 0		Glasgow	30 0 0	
50 0 0		Liverpool	100 0 0	
25 0 0		Toronto	—	
120 0 0		Montreal	60 0 0	
30 0 0		South Wales	—	
55 0 0		Edinburgh	—	
—		Plastics Group	38 11 0	
81 7 6		Yorkshire	—	
—		Food Group	88 6 6	
160 10 0		Chemical Engineering Group	150 0 0	
30 0 0		Ottawa	—	
304 5 8		Local Representatives attending Council	261 4 7	
	1,386 3 2			1,243 2 1
	26 15 0	,, Annual General Meeting—Grant and Head Office Expenses		262 16 5
		,, Annual Reports—		
876 14 9		Expenditure	808 15 11	
674 10 2		*Less*: Sales and Advertisements	652 5 11	
	202 4 7			156 10 0
		,, Propaganda—		
—		Publicity	112 10 0	
—		Exhibitions	85 3 1	
				197 13 1
		,, Working Expenses—		
2,199 15 0		Salaries and Pension	2,241 13 0	
499 0 4		Rent, Lighting and Cleaning	507 1 9	
240 6 8		Stationery and Binding	209 14 11	
560 15 8		Postages, Telephone and Sundry Expenses	412 7 3	
2 4 7		Bank Charges	2 11 8	
20 16 4		Depreciation	28 1 1	
	3,531 18 7			3,396 9 8
	£23,166 14 10			£22,271 11 5

INCOME.

1931 £ s. d.		1932 £ s. d.	1932 £ s. d.
9,472 12 2	By Members' Annual Subscriptions for 1932	8,929 9 5	
	,, Arrears paid during year	107 12 0	
			9,037 1 5
	,, *Journal*—		
7,859 1 10	Advertisements	6,884 17 9	
3,875 3 2	Subscriptions	3,749 19 4	
513 4 1	Extra Copies and Reprints	501 18 2	
171 9 4	Abstracts (including £26 17*s.* 6*d.* for previous years)	174 14 9	
			11,311 10 0
686 15 0	,, Dividends and Interest on Investments, gross		701 5 8
103 10 7	,, Bank Interest		86 15 1
—	,, Grant from Messel Fund for share of expenses of Bureau of Chemical Abstracts as, *per contra*		500 0 0
—	,, *Jubilee Fund*—		
	Refund of Guarantors' Dividends	42 16 2	
	Amount received for postages on Jubilee No. of Journal, Handbook, etc.	86 6 3	
			129 2 5
486 18 8	,, Balance, being Excess of Expenditure over Income for the Year		505 17 0
£23,166 14 10			

BALANCE SHEET AS AT 31st DECEMBER, 1932.

	£ s. d.	£ s. d.
Sundry Creditors		955 0 1
Subscriptions to the Society and *Journal* paid in advance		3,084 0 1
Reserve for Decennial Index, 1923—1932—		
as at 31st December, 1931	1,750 0 0	
Less: Expenditure during 1932	100 0 0	
		1,650 0 0
Life Composition Fees (*per contra*)		233 0 3
Accumulated Fund—		
Balance as at 31st December, 1931	12,467 4 7	
Add: Increase in Value of Investments	2,964 4 7	
	15,431 9 2	
Less: Excess of Expenditure over Income for the year as per Income and Expenditure Account	505 17 0	
		14,925 12 2
		£20,847 12 7

Cost £ s. d.	£ s. d.		£ s. d.	£ s. d.
		Sundry Debtors for Advertisements, etc., Refund of Income Tax and Payments in Advance	2,118 19 0	
		Less: Reserve for Bad and Doubtful Debts on Advertisements	150 0 0	
				1,968 19 0
		Stock of *Journal* Paper		108 10 3
		Stock of *Journals*—Nominal Value		200 0 0
		Stock of Annual Reports on Applied Chemistry, Vols. II, III, IV, V, VI, VII, IX, X, XI, XII, XIII, XIV, XV and XVI, as valued by Secretary		352 9 9
		Subscriptions in arrear, estimated to produce		75 0 0
		Cash at Midland Bank	1,914 10 10	
		Cash in Hand	21 19 1	
				1,936 9 11
		Investments at Market Value, viz.:—		
1,051 1 6	1,050 0 0	4 per cent. Funding Loan, 1960-90	1,139 5 0	
700 0 0	724 8 0	India 3½ per cent. Stock	637 9 5	
700 0 0	834 9 2	India 3 per cent. Stock	634 3 9	
2,327 1 7	2,502 13 11	Metropolitan 3 per cent. Consolidated Stock	2,502 13 11	
1,122 3 1	1,277 4 8	New South Wales 3 per cent., 1935	1,238 18 4	
870 0 0	1,000 0 0	New Zealand 3 per cent., 1945	910 0 0	
661 0 2	929 5 0	Conversion Stock 3½ per cent., 1961	919 19 2	
1,700 18 5	1,800 0 0	3½ per cent. War Bonds, 1929-47	1,777 10 0	
507 0 0	600 0 0	Gas Light & Coke Co. 3 per cent. Debenture Stock	474 0 0	
1,629 14 5	1,509 0 0	London & North Eastern Railway 4 per cent. 2nd Guaranteed Stock	807 6 6	
862 0 0	1,000 0 0	London & North Eastern Railway 3 per cent. Debenture Stock	630 0 0	
1,187 4 0	600 0 0	London Midland & Scottish Railway 4 per cent. Guaranteed Stock	447 0 0	
	460 0 0	London Midland & Scottish Railway 4 per cent. Preference Stock	167 18 0	
1,762 10 0	1,250 0 0	Great Western Railway 5 per cent. Consolidated Guaranteed Stock	1,331 5 0	
899 17 5	813 0 0	London & North Eastern Railway 4 per cent. 1st Guaranteed Stock	532 10 3	
492 10 2	464 0 0	London & North Eastern Railway 4 per cent. Debenture Stock	378 3 2	
746 7 2	605 0 0	Southern Railway, 5 per cent. Preference Stock	402 16 6	
922 10 0	1,000 0 0	Metropolitan Water Board "B" Debenture Stock	890 0 0	
18,141 17 11				15,880 10 0
Depreciation = 12·46% on cost.		Life Composition Fees:—		
		Investments at cost—		
	125 0 0	4 per cent. Treasury Bonds, Registered	126 2 9	
	98 8 4	4 per cent. Consolidated Loan	106 1 0	
			232 3 9	
		(Market Value at 31st December, 1932 £235 13*s.* 3*d.*)		
		Cash un-invested	16 6	
				233 0 3
		Office Furniture	115 5 6	
		Less: Depreciation for the year	23 1 1	
				92 4 5
				£20,847 12 7

"MESSEL FUND."

INCOME AND EXPENDITURE ACCOUNT FOR YEAR ENDED 31ST DECEMBER, 1932.

1931 s.	1931 d.	1931 £	1931 s.	1931 d.	EXPENDITURE.	£	s.	d.	£	s.	d.
					To Sundry Grants—						
0	0				,, International Association for Testing Materials	5	0	0			
0	0				,, Newcastle Chemical Industry Club	5	0	0			
3	0				,, British National Committee World Power Conference	3	3	0			
0	0				,, Chemical Society's Library	100	0	0			
—					,, Bureau of Chemical Abstracts	500	0	0			
0	0				,, Federal Council for Chemistry	—					
0	0				,, S.C.I. Jubilee Fund (Loan)	—					
0	0				,, Manchester Faraday Centenary	—					
		433	3	0					613	3	0
		17	12	0	,, Audit Fee				5	0	0
		62	2	0	,, Jubilee Memorial Lectures—Fees and Expenses				13	19	2
		—			,, Messel Medal and Expenses				69	3	0
		36	10	0	,, Special Grant—John Gray Scholar (non-recurrent)				—		
		1,170	11	7	,, Balance, being Excess of Income over Expenditure for the year				1,023	6	2
		1,719	18	7					£1,724	11	4

1931 £	s.	d.	INCOME.	£	s.	d.
1,460	3	8	By Dividends and Interest, Gross	1,720	14	11
9	14	11	,, Bank Interest	3	16	5
250	0	0	,, Refund of Loan to Society of Chemical Industry—Jubilee Account	—		
1,719	18	7		£1,724	11	4

BALANCE SHEET AS AT 31ST DECEMBER, 1932.

	£	s.	d.	£	s.	d.
apital Account— As at 31st December, 1931				18,435	8	9
undry Creditors				7	2	0
ncome and Expenditure Account—						
Balance at 31st December, 1931	9,861	18	5			
Add: Excess of Income over Expenditure for the year	1,023	6	2			
				10,885	4	7
				£29,327	15	4

£	s.	d.	Investments—	£	s.	d.	£	s.	d.
			(a) Original Fund at Value at date of Transfer—						
1,580	0	0	Metropolitan Water Board, Staines Reservoir Guaranteed Debenture Stock	766	6	0			
1,000	0	0	Metropolitan Water Board, Grand Junction Waterworks, 3½ per cent. Debenture Stock	535	0	0			
720	0	0	London Electric Railway 4 per cent. Debenture Stock	435	12	0			
600	0	0	London & North Eastern Railway 4 per cent. Guaranteed Stock	381	0	0			
15,364	0	0	War Loan 3½ per cent., 1929–47	13,422	7	4			
1,577	15	0	Conversion Loan 3½ per cent.	969	2	2			
1,970	0	0	Conversion Loan 5 per cent., 1944–64	1,926	1	3			
							18,435	8	9
			(b) Purchased out of Income at cost—						
686	18	11	Conversion Loan 3½ per cent.	480	17	10			
1,026	17	1	Conversion Loan 4½ per cent., 1940–44	1,000	0	0			
2,387	8	3	War Loan 3½ per cent., 1929–47	2,350	0	0			
1,000	0	0	Palestine Government 5 per cent. Guaranteed Stock, 1942–67	1,022	13	0			
5,247	17	1	Conversion Loan 5 per cent., 1944–64	5,439	5	10			
							10,292	16	8
			(Market Value of Securities at 31st December, 1932, £33,785 3s. 6d.)				28,728	5	5
			Sundry Debtor for refund of Income Tax on Investment Interest				36	16	0
			Cash on Deposit at Midland Bank				582	13	11
							£29,327	15	4

the Members of the Society of Chemical Industry.

We have audited the foregoing Balance Sheet of the Society, dated the 31st December, 1932, as also that of the Messel Fund, with the books and vouchers of the Society, and have verified the Investments, and are of opinion that such Balance Sheets correctly set forth the financial position of the Society and of the Fund at the 31st December, 1932.

FREDERICK'S PLACE, OLD JEWRY, LONDON, E.C.2.
3rd May 1933.

PRICE, WATERHOUSE & CO.

W. J. LEONARD BEQUEST ACCOUNT (INCOME).

CASH ACCOUNT FOR YEAR TO 31st DECEMBER, 1932.

	£	s.	d.		£	s.	d.
To Balance 1st January, 1932	0	5	10	By Purchase of £297 6s. 8d. 3½% Conversion Loan	279	15	0
„ Dividends received from Trustees, Gross	226	4	10	„ Balance at 31st December, 1932	5	5	4
„ Dividends received from Investments, net	7	11	8				
„ Income Tax refunded 1931–1932	50	18	0				
	£285	0	4		£285	0	4
Investments held on a/c. of Income £532 9s. 4d. 3½% Conversion Loan at cost	454	16	0				

JOHN GRAY JUBILEE SCHOLARSHIP ACCOUNT.

CASH ACCOUNT FOR YEAR TO 31st DECEMBER, 1932.

	£	s.	d.		£	s.	d.
To Dividends, Gross on £2,083 6s. 8d. Conversion 3½% Loan	72	0	1	By Balance at 1st January, 1932	0	10	0
				„ Scholarship Awards	71	10	0
				„ Balance at 31st December, 1932	0	0	1
	£72	0	1		£72	0	1

CHEMICAL ENGINEERING GROUP.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1932.

EXPENDITURE.	£	s.	d.	£	s.	d.	INCOME.	£	s.	d.	£	s.	d.
To Rent and Salaries				360	0	0	By Members' Subscriptions for 1932	463	1	0			
„ Printing and Stationery				156	14	7	„ Arrears paid during year	17	17	0			
„ Reserve for Publishing 1932 Proceedings				60	0	0					480	18	0
„ Postages and Telegrams				35	19	7	„ Society of Chemical Industry—						
„ Meetings	75	7	11				General Grant	150	0	0			
Reserve for Meetings at Newcastle	60	0	0				Printing Grant, 1932	150	0	0			
				135	7	11					300	0	0
„ Audit Fee				10	10	0	„ Sales of Publications				12	14	8
„ Miscellaneous Expenses—							„ Bank Interest				3	9	0
Travelling	5	8	2										
General	15	3	4										
				20	11	6							
„ Depreciation on Furniture				3	7	9							
Balance being excess of income over expenditure for the year				14	10	4							
				£797	1	8					£797	1	8

BALANCE SHEET AS AT 31st DECEMBER, 1932.

	£	s.	d.	£	s.	d.		£	s.	d.	£	s.	d.
To Sundry Creditors	88	13	9				By Cash on Deposit Account	300	0	0			
„ Reserve for Publishing Proceedings 1931 and 1932	309	11	9				„ Cash on Current Account	88	4	5			
Reserve for Newcastle Meeting	60	0	0								388	4	5
				458	5	6	„ Office Furniture—						
„ Subscriptions Paid in Advance				7	15	0	Balance as at 31st December, 1931	33	17	7			
„ Income and Expenditure Account—							*Less* Depreciation at 10 per cent. per annum	3	7	9			
Balance at 31st December, 1931	125	13	5								30	9	10
Add Excess of Income over Expenditure for the year	14	10	4				„ Sundry Debtors				187	10	0
				140	3	9							
				£606	4	3					£606	4	3

AUDITORS' REPORT.

We have examined the above Balance Sheet and accompanying Revenue Account of the Chemical Engineering Group of the Society of Chemical Industry, dated 31st December, 1932, with the books and vouchers of the Group, and have obtained all the information and explanations we have required. We are of opinion that the above Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Group's affairs, according to the best of our information and the explanations given to us, and as shown by the books of the Group.

PRICE, WATERHOUSE & CO.

3, FREDERICK'S PLACE, OLD JEWRY, LONDON, E.C.2.

27th March, 1933.

BUREAU OF CHEMICAL ABSTRACTS.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31st DECEMBER, 1932.

EXPENDITURE.

	£ s. d.	£ s. d.	£ s. d.
To Salaries—			
Chemical Society:			
Half Common	506 5 0		
Pure	450 0 0		
Index	280 12 6		
		1,236 17 6	
Society of Chemical Industry:			
Half Common	506 5 0		
Applied	450 0 0		
Index	124 8 10		
		1,080 13 10	
			2,317 11 4
,, Postages—			
Chemical Society:			
Half Common	47 0 2		
Pure	14 9 7		
		61 9 9	
Society of Chemical Industry:			
Half Common	47 0 2	47 0 2	
			108 9 11
,, Abstractors' Fees—			
Chemical Society: Pure		1,180 7 9	
Society of Chemical Industry: Applied		1,049 15 11	
			2,230 3 8
,, Printing Index			
Chemical Society	553 16 1		
Society of Chemical Industry	648 2 3		
		1,201 18 4	
,, Paper for Index			
Chemical Society	112 17 9		
Society of Chemical Industry	155 3 9		
		268 1 6	
,, Distribution and Banding Index			
Chemical Society:			
Distribution: Fellows	74 9 11		
Distribution: Subscribers	16 9 10		
Banding: Fellows	20 16 4		
Banding: Subscribers	4 12 2		
Society of Chemical Industry	180 18 3		
		297 6 6	
			1,767 6 4
,, Paper—			
Society of Chemical Industry: Applied			330 13 8
,, American Patents—Society of Chemical Industry: Applied			98 17 2
,, Miscellaneous—(All items Half Common)			
Chemical Society:			
Printing and Stationery	30 19 2		
Travelling	– 4 2		
General Expenses	9 9 5		
Sundry Journals	12 15 8		
		53 8 5	
Society of Chemical Industry:			
Printing and Stationery	30 19 2		
Travelling	– 4 3		
General Expenses	9 9 5		
Sundry Journals	12 15 7		
		53 8 5	
			106 16 10
			£6,959 18 11

INCOME.

	£ s. d.	£
By Sales of Abstracts		27
,, Society of Chemical Industry	3,644 13 5	
Less: Share of Sales of Abstracts	13 16 3	
		3,630
,, Chemical Society	3,315 5 6	
Less: Share of Sales of Abstracts	13 16 3	
		3,301
		£6,959

BALANCE SHEET AS AT 31st DECEMBER, 1932.

	£ s. d.	£ s. d.
To Amounts received for 1933 Publications		16 4 0
,, Sundry Creditors—		
Audit Fee	7 7 0	
Postages	5 13 10	
Paper	22 15 0	
Stationery	14 16 2	
Society of Chemical Industry	58 8 2	
Chemical Society	173 2 5	
		282 2 7
		£298 6 7

	£ s. d.	£
By Stock of P… Hand		17
,, Cash at Bank	259 11 7	
,, Cash in Hand	21 14 8	
		281

We report that we have examined the above Balance Sheet with the Books and Vouchers of the Bureau, and have obtained all the informati… explanations we have required. We are of the opinion that such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the … of the Bureau's affairs at December 31, 1932, according to the best of our information and the explanations given to us, and as shown by the bo… the Bureau.

3, Frederick's Place, Old Jewry, London, E.C.2.
20th January, 1933.

PRICE, WATERHOUSE…